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(71)(72) Applicants and Inventors: HOLAKOVSZKY, László [HU/HU]; Pattantyús u. 6, H–1221 Budapest (HU). NAGYKÁLNAI, Endre [HU/HU]; Törökvész út 78/B, H–1025 Budapest (HU).

(74) Agent: KOVÁRI, György; Advopatent Office of Patent Attorneys, Fő utca 19, H–1011 Budapest (HU).

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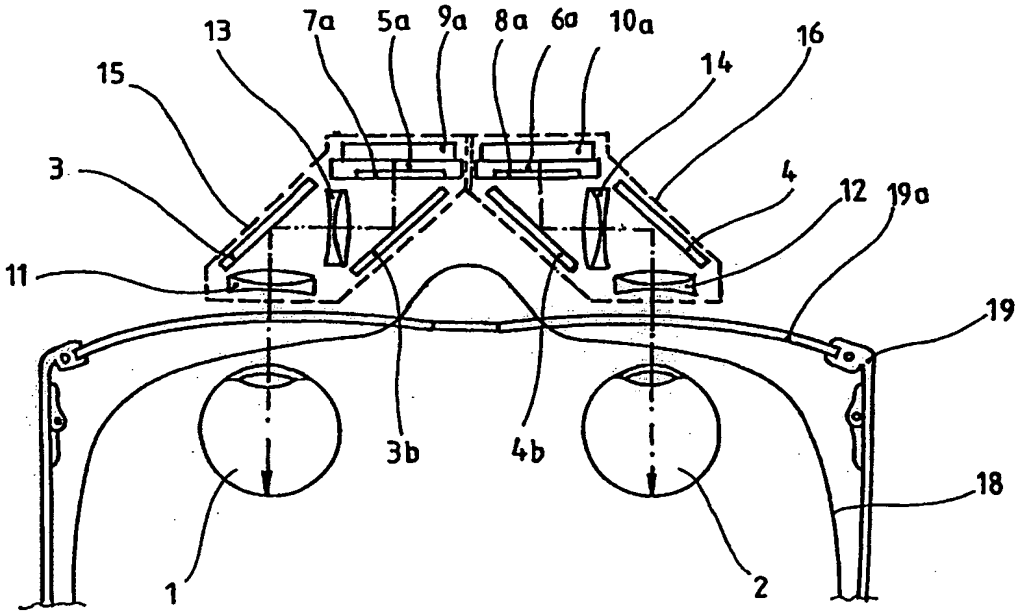

(57) Abstract

The imaging device has two screens and an optical system consisting of pre–eye mirrors and lenses for transmitting beams of light from the screens to the eyes. The device is characterized in that a lens system consisting of at least three members is arranged in each light path starting from the screens (7, 8) and reflected by the pre–eye mirrors (3, 4) into the pupils of the eyes (1, 2); two members of the lens system, a converging lens and a diverging lens, are placed side by side directly or with a distance, said members forming together a corrected subsystem (13, 14); and the third member of the lens system is placed separately from said subsystem and comprises a converging lens, optionally combined with a diverging lens (11, 12).

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OPTICAL SYSTEM FOR HEAD UP DISPLAY

The invention relates to an imaging device having two display panels, and optical elements for transmitting the image produced on the display panels into both eyes.

Several head worn imaging devices are known in the art. The majority of said devices comprises two miniature display panels, one for each eye; the display panels are arranged in front of the eyes - which entails a disadvantageously protruding construction -, or on both sides; in the latter case the image is reflected into the eyes by mirrors placed in front of the pupils. Since the mirrors are necessary to construct a compact device, and the position of the mirrors and the distance between them are given, the two mirrors are the elements limiting the possibility to reduce the size of the device; therefore it is expedient to place the display panels between the mirrors. Lens systems consisting of magnifying lenses are used to focus the beams of light starting from the screens into the eyes. Since unfocused, discoloured, deformed images cannot be allowed when displaying video pictures, the focusing optical elements must comply with high requirements.

Several attempts have been made during the recent years to construct a suitable optical

system to meet the requirements. According to one of the known solutions (US Patent Specification No. 5 276 471, Fig. 3), a single convex lens with short focal length is arranged in the light path between LCDs and the pupils of the eye. It is also known (US Patent Specification No. 5 371 556, Fig. 8/b) that the lens system consists of two convex lens members, where one of said lenses is arranged between an LCD and a mirror, and the other one between the mirror and the eye. Fig. 27 of the published Japanese Patent Specification No. 06331927A also shows a device having a lens system consisting of two convex lens members, where one of said lenses is arranged between the eye and a mirror, and the other one between the mirror and an LCD, directly on the surface of the LCD. Finally, according to Fig. 1 of the published Japanese Patent Specification No. 07092423A, the focusing element is a single convex lens arranged between the eye and a mirror.

A common drawback of the above mentioned devices is that the image is produced by means of simple magnifying lenses, and the distortions of the image produced by the lenses are not corrected at all. In this respect, a lens system consisting of two converging lens members is not better because the second lens member only continues to magnify the image focused by the first lens member, thereby increasing the defects of the image. The result is that the image is unfocused, deformed, deflected, and the edges are discoluored.

Another common drawback of the above mentioned known solutions is that only a single light source placed in the middle of the device is used to illuminate both LCDs. Consequently, when the user sets the pre-eye lenses - together with the LCDs having a constant distance from the pre-eye lenses - in front of the pupils in accordance with the distance between the pupils (IPD), the distances between the LCDs and the light source, and between the pupil and the light source, respectively, change with the result that the brightness of the screens changes, too, which is rather disturbing during the setting; in addition, the same device cannot be worn by persons having small and big IPDs, respectively, because the transillumination can be too intensive for persons with small IPD, and too faint for persons with big IPD.

A further common feature of the described prior devices is a bulky outer cover enclosing the front part of the head in order to enable the user to wear the device in the manner as a pair of glasses can be worn. It is disadvantageous, however, that the cover occupies the ridge of the nose and the ears; consequently, spectacled persons cannot wear the device together their own glasses or, at least, wearing the imaging device is very unconfortable.

It is therefore the object of this invention to provide an imaging device which - in addition its small size and a large-scale magnification - reduces the defects in the image to a minimum, and ensures a constant image brightness at any

setting. Another object of the invention is to make the device suitable for being fixed to a pair of glasses; in this case, spectacled persons can wear the device mounted on their own glasses, and non-spectacled persons can fix the device on the head by means of a spectacle frame having lenses of 0 dioptre. A further important object of the invention to provide a fixing element enabling the device to be fixed easily and simply to any pair of glasses.

It is also an object of the invention to provide the smallest and lightest device possible so that it can be worn comfortably on the glasses, leaving place for the ridge of the nose, and it can be built into other equipments of information technology, e.g. mobile phones.

The invention is based on the recognition that a lens system consisting of at least three members should be used in order to eliminate the defects in the image or to reduce them to a minimum; at least two members of the lens system should combine converging and diverging lenses, i.e. form a corrected system of converging and diverging lenses correcting the chromatic aberration on the wave length of at least two primary colours. To ensure an image of constant brightness, flat display panels should be used, each emitting light or being transilluminated separately. The volume of the device can be reduced to a minimum if the light paths between the displays and the pre-eye mirrors are deflected on both sides by means of a first mirror placed parallel to the corresponding pre-

eye mirror. The simplest means to fix the device to a pair of glasses is a clip adapter made of a flexible sheet strip, and having clips on the ends and an upright tongue in the middle. The opposite of the tongue can be a nest formed by e.g. a bracket with two hook-like ribs on the side facing the user's face. Finally, in order to minimize the volume of the head-worn unit, the operating circuits of the display panels should be placed separately from the device (e.g. clipped to the clothes or put in the pocket), but connected to it by means of an aerial cable.

The object of this invention is accomplished by an imaging device having two screens and an optical system consisting of pre-eye mirrors and lenses for transmitting beams of light from the screens to the eyes. The device is characterized in that a lens system consisting of at least three members is arranged in each light path starting from the screens and reflected by the pre-eye mirrors into the pupils of the eyes; two members of the lens system, a converging lens and a diverging lens, are placed side by side directly or with a distance between them, said members forming together a corrected subsystem; and the third member of the lens system is placed separately from said subsystem and comprises a converging lens, occasionally combined with a diverging lens. The lens members are arranged partly between the pre-eye mirror and the pupil, partly between the pre-eye mirror and the screen in order to focus the beam of light in several steps; therefore each lens or each group of

lenses refracts the rays of light passing through the periphery of the lens by a smaller angle, advantageously reducing the defects in the image. The resulting focal length of the lens system corresponds to the distance between the screen and the image-side main plane of the single magnifying lens being theoretically equivalent to the lens system, so that an infinitely distant image can be viewed without accommodation. Expediently, the lens between the pre-eye mirror and the pupil is placed close to the mirror to have a solid device which can be mounted compactly on the glasses.

According to our recognition, the lens or lens system between the pre-eye mirror and the screen should be placed close to the pre-eye mirror to achieve the biggest magnification possible, since the magnification is practically zero when the lense is lying on the screen, and increases in proportion to the distance from the screen. Each display is an illuminator emitting light, e.g. a display of active matrix electroluminescent (AMEL) type, or a transparent, e.g. LCD display transilluminated by a separate light source placed close to the display.

In a preferred embodiment of the device, the subsystems consisting of the converging and diverging lenses are arranged between the screens and the pre-eye mirrors; and the converging lenses forming the third member of the lens system are arranged between the pre-eye mirrors and the pupils.

In another embodiment of the device, the two-member subsystems arranged between the screens and the pre-eye mirrors consist - along the path of the light - of convex converging lenses of a smaller refractive index and meniscus-shaped diverging lenses of a bigger refractive index; the converging lenses forming the third member between the pre-eye mirrors and the pupils are planoconvex or meniscus-shaped converging lenses, the non-convex sides of which face the pupils. Thereby the angle of incidence ε of the outside rays of light arriving from the screen, i.e. the angle between the incident ray and the normal at the point of incidence, and the angle of departure ε_1 of the same ray, i.e. the angle between the emerging ray and the normal at the point of emergence, differ only slightly from each other, or they are equal in the optimal case, and the sum of them is minimal beside a given magnification of the lens; as a result, the defects in the image are reduced.

In a further preferred embodiment, the converging lenses forming the third members are placed between the screens and the pre-eye mirrors; and the two-member subsystems consisting of converging and diverging lenses are arranged between the pre-eye mirrors and the pupils. Expediently, the two-member subsystem comprises two lens cemented together: a convex converging lens of smaller refractive index, made of e.g. crown glass, and a meniscus-shaped diverging lens of bigger refractive index, made of e.g. flint glass; and the outer form of the lens system is

convex. If the members of the two-member lens systems have different focal length, but the difference between the distances of intersection is the same in opposite directions, the lens system corrects the aperture defect (spherical aberration), and reduces the field-deflection and the astigmatism. If the lens members - dependent on the kind of glass - have different dispersive power (Abbe number), and the focal points for two colours (e.g. blue and red) coincide, the lens system can be considered as free from chromatic aberration (achromatic lens system).

According to another possible embodiment, each display panel is transilluminated by a flat illuminator, or each display panel itself is an illuminator. The lens system can be constructed similarly as in the previous embodiment.

In a further possible embodiment, the lens system comprises two-member subsystems consisting of converging and diverging lenses; said subsystems are arranged both between the screens and the pre-eye mirrors and between the pre-eye mirrors and the pupils; thereby the aberrations can be further reduced. Expediently, the two-member subsystems arranged between the screens and the pre-eye mirrors consist - along the path or the light - of convex converging lenses of a smaller refractive index and biconcave diverging lenses of a bigger refractive index; the two-member subsystems between the pre-eye mirrors and the pupils consist of meniscus-shaped diverging lenses of a bigger refractive index and meniscus-shaped converging lenses of a smaller refractive

index, where the outer concave sides of the lenses of the subsystems face the pupils. Such a lens system reduces or even entirely corrects the astigmatism and the field-deflection (anastigmatic lens system), and reduces the spherical aberration, too.

According to another embodiment, the two-member subsystem arranged between the screen and the pre-eye mirror is a cemented achromatic pair of lenses consisting - along the path of the light - of a meniscus-shaped diverging lens of flint glass and a meniscus-shaped converging lens of crown glass; the lens system between the pre-eye mirror and the pupil is symmetrical to the other lens system between the screen and the pre-eye mirror. In this case, the whole lens system corrects the distortions at the edges of the image, reduces the defects in the colour-magnification causing blurred and discoloured edges, and reduces the spherical aberration and the sphero-chromatic aberration (i.e. the spherical aberration depending on the colour of the light, too).

The display panels with the screens are arranged either in the area between the pre-eye mirrors, parallel to each other, but back to back, or outside the area between the pre-eye mirrors, at the boundary of said area, side by side in the same plane, (with the screens) facing the same direction. The display panels either emit light or are transilluminated by means of a flat illuminator placed close behind the panels. If the display panels are arranged outside the

area between the pre-eye mirrors, at the boundary of said area, a further so called first mirror is arranged in the light path on both sides of the device; the first mirror is parallel to the corresponding pre-eye mirror and reflects the rays of light coming from the screen toward the pre-eye mirror. The left side display panel and the optional illuminator, the left side pre-eye mirror and the left side lenses are held together by a left side housing; similarly, the right side display panel and the optional illuminator, the right side pre-eye mirror and the right side lenses are held together by a right side housing. Said housings are fixed to a common framework, and at least one of said housings can be slided relative to the framework along guideways parallel to the line connecting the centres of the screens, so that the pre-eye mirrors can be set in front of the pupils.

The invention also relates to an imaging device having two screens and an optical system consisting of pre-eye mirrors and lenses for transmitting beams of light from the screens to the eyes. This device is characterized in that the two screens are arranged side by side, in the same plane, facing the same direction; in front of each screen, a first mirror is arranged defining an angle of 45°±10° relative to the plane of the screens, and an angle of 90°±20° relative to the other first mirror; accordingly, the first mirrors form a V-shape, the open side of which is turned away from the screens; the first mirrors project the light beams from the

screens onto the pre-eye mirrors arranged parallel to the first mirrors; and the pre-eye mirrors reflect said light beams further into the eyes of the viewer.

Expediently, the left side display panel, the left side first mirror, the left side pre-eye mirror and the left side lenses are held together by a left side housing; similarly, the right side display panel, the right side first mirror, the right side pre-eye mirror and the right side lenses are held together by a right side housing; and said housings are fastened to a common framework.

It is also advantageous, if a pair of glasses constitutes one of the elements fixing the device to the head, and the other fixing element is an adapter comprising upright guideways, preferably slides, fastening the common framework to the glasses; and the left side housing and the right side housing are connected to the common framework by means of horizontal guideways.

According to another embodiment, the adapter fixing the device to the glasses comprises a flexible strip 7-10 cm in length; said strip has widened ends bent back in U-shape to form two clip elements; and in the middle, the strip has a widened platform with a supporting tongue bent back in U-shape in the direction opposite to the direction of said clip elements. Expediently, the operating circuits of the display panels are placed separately from the head in a separate box or built together with the source of the video

signal, e.g. computer, video player, camera, or TV receiver.

Finally, in a preferred embodiment, two video signal inputs are provided on the separate box to receive the left side and right side video signals of the stereoscopic image to be displayed.

The described device can be built in an equipment of information technology (e.g. mobile phone, pager, palmtop computer, manager calculator), or it can be worn on the head. The intermediate elements enabling the device to be worn on the head are a pair of glasses and a fixing adapter with clips.

The present invention will now be described by way of examples with reference to the accompanying drawings, in which:

Fig. 1: a schematic top-view of a preferred embodiment of the device according to the invention, mounted on glasses;

Fig. 2: a preferred embodiment of the lens system of the device according to the invention, where the subsystems consisting of a converging lens and a diverging lens cemented together are arranged between the screens and the pre-eye mirrors, and the converging lenses are arranged between the pre-eye mirrors and the eyes;

Fig. 3: another preferred embodiment of the lens system of the device according to the invention, where the subsystems consisting of a converging lens and a diverging lens cemented together are arranged between the pre-eye mirrors and the eyes, and the converging lenses are

arranged between the screens and the pre-eye mirrors;

Fig. 4: an embodiment of the lens system of the device according to the invention, where the corrected subsystems consist of cemented pairs of lenses comprising a convex converging lens made of crown glass and a biconcave diverging lens made of flint glass, said pairs of lenses are arranged between the corresponding screens and pre-eye mirrors, and the third members of the lens system consist of a cemented pair of lenses comprising a meniscus-shaped converging lens made of crown glass and a meniscus-shaped diverging lens made of flint glass, said third members are arranged between the pre-eye mirrors and the eyes;

Fig. 5: a further embodiment of the lens system of the device according to the invention with corrigated subsystems consisting of cemented achromatic pairs of lenses comprising a meniscus-shaped diverging lens made of flint glass and a meniscus-shaped converging lens made of crown glass, said pairs of lenses are arranged between the screens and the pre-eye mirrors; the third members of the lens system consist of a cemented pair of lenses comprising a meniscus-shaped converging lens made of crown glass and a meniscus-shaped diverging lens made of flint glass, i.e. the third member - as a cemented achromatic pair of lenses - forms the reverse of the subsystem, and said third members are arranged between the pre-eye mirrors and the eyes;

Fig. 6: a perspective view of the device according to the invention mounted on glasses and put on the head of the user;

Fig. 7: a schematic top-view of a preferred embodiment of the device according to the invention comprising four mirrors, mounted on glasses, without the means fixing the device;

Fig. 8a: a perspective view of the device according to the invention with a bracket mounted on a common framework;

Fig. 8b: the other side of the device according to Fig. 8a;

Fig. 9a: a perspective view of a clip adapter for fixing the device according to the invention to glasses;

Fig. 9b: the other side of the adapter according to Fig. 9a;

Fig. 10: a perspective side-view of the device according to the invention mounted on glasses by means of the fixing adapter;

Fig. 11: a schematic view of the device according to the invention built into a mobile phone.

According to Fig. 1, pre-eye mirrors 3 and 4 are placed in front of the pupils of the eyes 1 and 2 looking forward when the device is used; flat display panels 5 and 6 are arranged between the pre-eye mirrors 3 and 4. The pre-eye mirrors 3 and 4, due to their angular position, reflect the light beams starting from the screens 7 and 8

of the display panels 5 and 6 into the pupils of the eyes 1 and 2, respectively. The display panels 5 and 6 are transilluminated by flat illuminators 9 and 10 placed close to the display panels 5 and 6; the illuminators 9 and 10 have a larger illuminating surface than the size of the screens 7 and 8. Between the pre-eye mirrors 3 and 4 and the pupils of the eyes 1 and 2, and close to the pre-eye mirrors 3 and 4, converging lenses 11 and 12 (in this embodiment pairs of converging lenses) are arranged; between the pre-eye mirrors 3 and 4 and the pupils, the optical axes of the converging lenses 11 and 12 coincide with the paths of the rays of light emitted from the centres of the screens 7 and 8 and traveling toward the centres of the pupils. Lens units 13 and 14 forming two-member corrected subsystems of the lens system according to the invention are placed between the pre-eye mirrors 3 and 4 and the screens 7 and 8, close to the pre-eye mirrors 3 and 4; between the screens 7 and 8 and the pre-eye mirrors 3 and 4, the optical axes of the lens units 13 and 14 coincide with the paths of the rays of light emitted from the centres of the screens 7 and 8 and traveling toward the centres of the corresponding pupils. The illuminator 9, the display panel 5, the lens unit 13, the pre-eye mirror 3 and the converging lens 11 are held together by a left side housing 15 which - in the embodiment according to Fig. 1 - surrounds the enumerated elements, but has an opening or window in front of the converging lens 11 to let the light beam through. Similarly, the illuminator

10, the display panel 6, the two-member lens unit 14 (subsystem), the pre-eye mirror 4 and the converging lens 12 are held together by a right side housing 16 which - in the embodiment according to Fig. 1 - surrounds the enumerated elements, but has an opening or window in front of the converging lens 12 to let the light beam through. The left side housing 15 and the right side housing 16 can be made of transparent or non-transparent material, and can have a half- or even a full-open construction. The left side housing 15 and the right side housing 16 are fixed to a framework 17 which, in the preferred embodiment, surrounds the neighbouring ends of the left side housing 15 and the right side housing 16 as an outer cover so that the left side housing 15 and the right side housing 16 can be pushed in and pulled out in line, as a drawer. The range of movement of the left side housing 15 and the right side housing 16 can be limited mechanically by stops. Advantageously, each housing can be moved on a length which is equal to the half of the difference between the commonly occuring biggest and smallest IPDs (55 and 75 mm); thereby the converging lenses 11 and 12 can be set in front of the pupils in horizontal direction for any user. The framework 17 is fixed to the head of the user by means of intermediate element(s). A possible intermediate element is e.g. a pair of glasses 19; the glasses 19 and the framework 17 are fixed together by means of another intermediate element, e.g. an adapter 20 having a slide so that the framework

17 can be slided up and down on the glasses 19. Due to the movability, the converging lenses 11 and 12 can be set in front of the pupils in vertical direction.

In Fig. 2, a cemented two-member subsystem of an at least three-member lens system is placed between the screens 7 and 8 and the pre-eye mirrors 3 and 4, respectively. The two-member subsystems comprise convex converging lenses 25 and 26 of a smaller refractive index and meniscus-shaped diverging lenses 27 and 28 of a bigger refractive index. Between the pre-eye mirrors 3 and 4 and the corresponding pupils, meniscus-shaped converging lenses 23 and 24 are arranged; the concave side of the converging lenses 23 and 24 is turned to the pupils. The converging lenses 23 and 24 form the third member of the three-member lens system.

In Fig. 3, convex converging lenses 29 and 30 forming the third members of the lens system are placed between the screens 7 and 8 and the pre-eye mirrors 3 and 4. Between the pre-eye mirrors 3 and 4 and the pupils 21 and 22, cemented two-member subsystems are arranged; these subsystems comprise convex converging lenses 31 and 32 of a smaller refractive index and meniscus-shaped diverging lenses 33 and 34 of a bigger refractive index.

In Fig. 4, four-member lens systems are shown; cemented two-member subsystems of the lens system is placed between the screens 7 and 8 and the pre-eye mirrors 3 and 4. These subsystems comprise convex converging lenses 35 and 36 of a

smaller refractive index and biconcave diverging lenses 37 and 38 of a bigger refractive index. The outer concave sides of the lens members are turned to the pre-eye mirrors. Between the pre-eye mirrors 3 and 4 and the pupils 21 and 22, another lens system is placed; this lens system comprises converging lenses 41 and 42 associated with diverging lenses; accordingly, the cemented two-member lens units comprise the meniscus-shaped diverging lenses 39 and 40 of a bigger refractive index and the meniscus-shaped converging lenses 41 and 42 of a smaller refractive index. The outer concave sides of the lenses of the lens system face the pupils 21 and 22.

In Fig. 5, a four-member lens system consists of cemented two-member subsystems; the two-member subsystems comprise meniscus-shaped diverging lenses 43 and 44 of a bigger refractive index and meniscus-shaped converging lenses 45 and 46 of a smaller refractive index. The outer concave sides of the lenses of the lens system face the pre-eye mirrors 3 and 4. Between the pre-eye mirrors 3 and 4 and the pupils 21 and 22, another lens system is placed, comprising converging lenses 49 and 50 associated with diverging lenses; accordingly, the cemented two-member lens units comprise the meniscus-shaped converging lenses 47 and 48 of a smaller refractive index and the meniscus-shaped diverging lenses 49 and 50 of a bigger refractive index. The outer concave sides of the lens members face the pre-eye mirrors 3 and 4.

In Fig. 6, a preferred embodiment of the device is shown where the operating circuits 51 of the display panels 5 and 6 - because of their weight and size - are placed separately, distant from the head 62, in a box 52 or built together with the source of the video signal (e.g. computer, video player, camera, TV receiver). The electric wires connected to the display panels 5 and 6 and to the optional illuminators 9 and 10 are realized as an aerial cable 53; advantageously, the aerial cable 53 is led on the glasses 19 backward to one of the sidepieces 54 and fixed there by means of a clip.

If sound is provided, too, it is transmitted to the ear 59 either by an earphone 58 mounted to the end of an earphone-cable 57 tapping off the aerial cable 53 at the branching 56, or by a loudspeaker 61 inserted into a widening part (indicated with broken lines) of the aerial cable 53. A stereophonic sound reproduction is also possible; in this case, the branching 56 is lowered to the height of the neck or chest, and the sound is transmitted from the branching 56 to each ear by means of cables and earphones.

According to Fig. 7, the two screens 7a, 8a are arranged side by side, in the same plane, facing the same direction. In front of each screen 7a, 8a, a first mirror 3b, 4b is arranged defining an angle of 45°±10° relative to the plane of the screens 7a, 8a, and an angle of 90°±20° between each other, forming a V-shape the open side of which is turned away from the screens 7a, 8a. The first mirrors 3b, 4b project

the light beams from the screens 7a, 8a onto the pre-eye mirrors 3, 4 arranged parallel to the first mirrors 3b, 4b; the pre-eye mirrors 3, 4 reflect said light beams further into the eyes 1 and 2, respectively, of the viewer. The display panel 5a and the optoinal illuminator 9a, the first mirror 3b, the lens unit 13 forming a two-member subsystem of the lens system, the pre-eye mirror 3 and the lens unit 11 comprising the third member of the lens system, i.e. a converging lens, are held together by a left side housing 15 which surrounds the enumerated elements, but has an opening or window in front of the lens unit 11 to let the light beam through. Similarly, the display panel 6a and the optional illuminator 10a, the first mirror 4b, the two-member lens unit 14 forming a subsystem, the pre-eye mirror 4 and the lens unit 12 comprising a converging lens as the third member of the lens system are held together by a right side housing 16 which surrounds the enumerated elements, but has an opening or window in front of the lens unit 12 to let the light beam through. The left side housing 15 and the right side housing 16 are fixed to a framework (not shown); advantageously, the framwork surrounds the housings as an outer cover so that the housings can be pushed in and pulled out in line, parallel to themself, as a drawer. The device can be fixed to the glasses 19 similarly as described in connection with Fig. 1.

According to Figs. 8a and 8b, a stiffened bracket 65 is fixed to the framework 17; the

bracket 65 comprises hook-like ribs 66 and 67 serving as sliding guideways. A recess 68 is formed on the framework 17 for the ridge of the nose of the user.

Figs. 9a and 9b show a universal clip adapter for fixation; this adapter can be connected to any glasses. On each end of the fixing adapter, a clip element 70 and 71, respectively, is arranged; the clip elements are flexible and can be pressed and snapped on the spectacle frame above the centre of the lenses. The clip elements 70 and 71 are connected by a bridge 69 having a center part widened into a platform 73; from the lower part of the platform 73, a supporting tongue 72 bends back by 180° into an upright position. Preferably, the fixing adapter is made of a transparent material so that it does not intercept the view of the person wearing the glasses.

Fig. 10 shows the glasses with the fixing adapter and the monitor, fastened together.

In Fig. 11 a mobile phone is shown with a built-in device according to Fig. 7.

It is to be understood that while only certain preferred embodiments of the present invention have been described and illustrated herein, numerous variations or alterations can be made without departing from the spirit and scope of the invention defined by the appended claims.

Claims:

1. Imaging device having two screens and an optical system consisting of pre-eye mirrors and lenses for transmitting beams of light from the screens to the eyes,
c h a r a c t e r i z e d in that a lens system consisting of at least three member is arranged in each light path starting from the screens (7, 8; 7a, 8a) and reflected by the pre-eye mirrors (3, 4) into the pupils of the eyes (1, 2); two members of the lens system, a converging lens and a diverging lens, are placed side by side directly or with a distance, said members forming together a corrected subsystem; and the third member of the lens system is placed separately from said subsystem and comprises a converging lens, optionally combined with a diverging lens.

2. Device as claimed in claim 1,
c h a r a c t e r i z e d in that each display panel (5, 6) is transilluminated by a flat illuminator (9, 10; 9a, 10a), or each display panel itself is an illuminator.

3. Device as claimed in claim 1 or 2,
c h a r a c t e r i z e d in that the subsystems consisting of the converging and diverging lenses are arranged between the screens (7, 8) and the pre-eye mirrors (3, 4); and the converging lenses (23, 24) forming the third member of the lens system are arranged between the pre-eye mirrors (3, 4) and the pupils (21, 22).

4. Device as claimed in claim 3,
c h a r a c t e r i z e d in that the two-member subsystems arranged between the screens (7, 8) and the pre-eye mirrors (3, 4) consist - along the path of the light - of convex converging lenses (25, 26) of a smaller refractive index and meniscus-shaped diverging lenses of a bigger refractive index; the converging lenses (23, 24) forming the third member between the pre-eye mirrors (3, 4) and the pupils (21, 22) are planoconvex or meniscus-shaped converging lenses, the non-convex sides of which are turned to the pupils (21, 22).

5. Device as claimed in claim 1 or 2,
c h a r a c t e r i z e d in that the converging lenses (23, 24) forming the third members are placed between the screens (7, 8) and the pre-eye mirrors (3, 4); and the two-member subsystems consisting of converging and diverging lenses are arranged between the pre-eye mirrors (3, 4) and the pupils (21, 22).

6. Device as claimed in claim 5,
c h a r a c t e r i z e d in that the lenses forming the third member of the lens system placed between the screens (7, 8) and the pre-eye mirrors (3, 4) are convex converging lenses (29, 30); and the two-member subsystems between the pre-eye mirrors (3, 4) and the pupils (21, 22) consist of convex converging lenses (31, 32) of a smaller refractive index and meniscus-shaped diverging lenses (33, 34) of a bigger refractive

index, where said converging and diverging lenses are advantageously cemented together.

7. Device as claimed in claim 1 or 2,
c h a r a c t e r i z e d in that the lens system comprises two-member subsystems consisting of converging and diverging lenses which are placed both between the screens (7, 8) and the pre-eye mirrors (3, 4), and between the pre-eye mirrors (3, 4) and the pupils (21, 22).

8. Device as claimed in claim 7,
c h a r a c t e r i z e d in that the two-member subsystems arranged between the screens (7, 8) and the pre-eye mirrors (3, 4) consist - along the path of the light - of convex converging lenses (35, 36) of a smaller refractive index and biconcave diverging lenses (37, 38) of a bigger refractive index; the two-member subsystems between the pre-eye mirrors (3, 4) and the pupils (21, 22) consist of meniscus-shaped diverging lenses (39, 40) of a bigger refractive index and meniscus-shaped converging lenses (41, 42) of a smaller refractive index, where the outer concave sides of the lenses of the subsystems face the pupils (21, 22).

9. Device as claimed in any one of claims 1, 2 and 7,
c h a r a c t e r i z e d in that the two-member subsystems arranged between the screens (7, 8) and the pre-eye mirrors (3, 4) consist - along the path of the light - of meniscus-shaped

diverging lenses (43, 44) of a bigger refractive index and meniscus-shaped converging lenses (45, 46) of a smaller refractive index, where the outer concave sides of the subsystems face the pre-eye mirrors (3, 4); the two-member subsystems between the pre-eye mirrors (3, 4) and the pupils (21, 22) consist of meniscus-shaped converging lenses (47, 48) of a smaller refractive index and meniscus-shaped diverging lenses (49, 50) of a bigger refractive index, where the outer concave sides of the subsystems face the pre-eye mirrors (3, 4).

10. Device as claimed in any one of claims 1-9, c h a r a c t e r i z e d in that the left side display panel (5) and the optional illuminator (9), the left side pre-eye mirror (3) and the left side lenses are held together by a left side housing (15); similarly, the right side display panel (6) and the optional illuminator (10), the right side pre-eye mirror (4) and the right side lenses are held together by a right side housing (16), and said housings (15, 16) are fixed to a common framework (17).

11. Imaging device having two screens and an optical system consisting of pre-eye mirrors and lenses for transmitting beams of light from the screens to the eyes,
c h a r a c t e r i z e d in that the two screens (7a, 8a) are arranged side by side, in the same plane, facing the same direction; in front of each screen (7a, 8a), a first mirror

(3b, 4b) is arranged defining an angle of 45°±10° relative to the plane of the screens (7a, 8a), and an angle of 90°±20° relative to the other first mirror, said first mirrors (3b, 4b) form a V-shape with an open side turned away from the screens; the first mirrors (3b, 4b) project the light beams from the screens (7a, 8a) onto the pre-eye mirrors (3, 4) arranged parallel to the first mirrors (3b, 4b); and the pre-eye mirrors (3, 4) reflect said light beams further into the eyes (1, 2) of the viewer.

12. Device as claimed in claim 7,
c h a r a c t e r i z e d in that the left side display panel (5a), the left side first mirror (3b), the left side pre-eye mirror (3) and the left side lenses (11, 13) are held together by a left side housing (15); similarly, the right side display panel (6a), the right side first mirror (4b), the right side pre-eye mirror (4) and the right side lenses are held together by a right side housing (16), and said housings (15, 16) are fixed to a common framework (17).

13. Device as claimed in claim 11 or 12,
c h a r a c t e r i z e d in that one of the elements fixing the device to the head (18) is a pair of glasses (19), and the other fixing element is an adapter (20) comprising upright guideways, preferably slides, fastening the common framework (17) to the glasses (19).

14. Device as claimed in any one of claims 11-13,

c h a r a c t e r i z e d in that the left side housing (15) and the right side housing (16) are connected to the common framework (17) by means of horizontal guideways.

15. Device as claimed in any one of claims 11-14, c h a r a c t e r i z e d in that the adapter fixing the device to the glasses comprises a flexible strip 7-10 cm in length, said strip having widened ends bent back in U-shape to form two clip elements (70, 71); and the middle part of the strip is a widened platform (73) with a supporting tongue (72) bent back in U-shape in the direction opposite to the direction of said clip elements (70, 71).

16. Device as claimed in any one of claims 11-15, c h a r a c t e r i z e d in that the operating circuits (51) of the display panels are placed separately from the head (18) in a separate box (52) or built together with the source of the video signal, e.g. computer, video player, camera, or TV receiver.

17. Device as claimed in any one of claims 11-16, c h a r a c t e r i z e d in that two video signal inputs (63, 64) are provided on the separate box (52) to receive the left side and right side video signals of the stereoscopic image to be displayed.

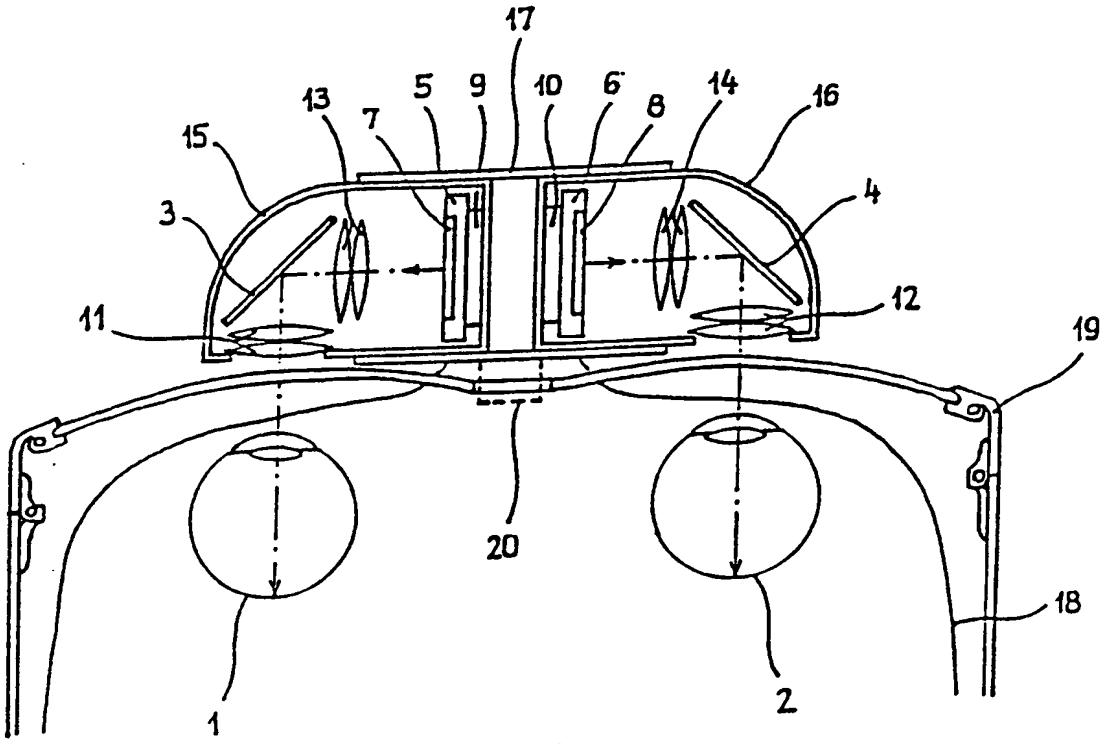
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Fig. 1

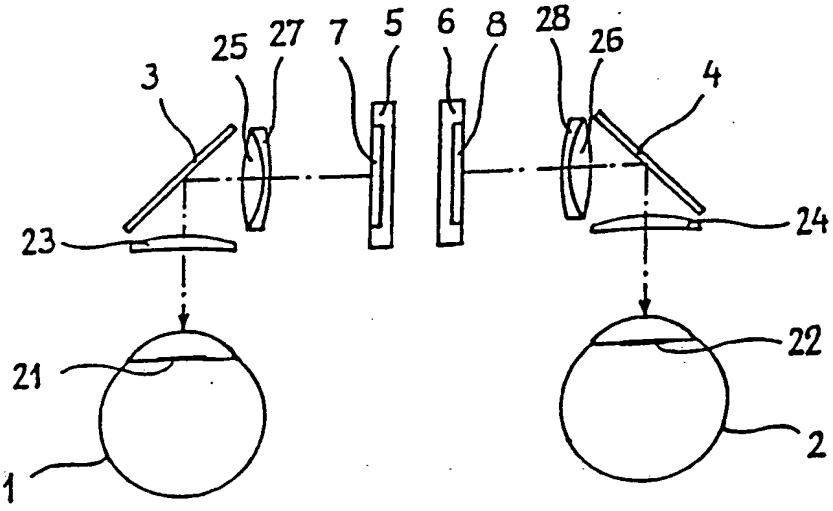
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Fig. 2

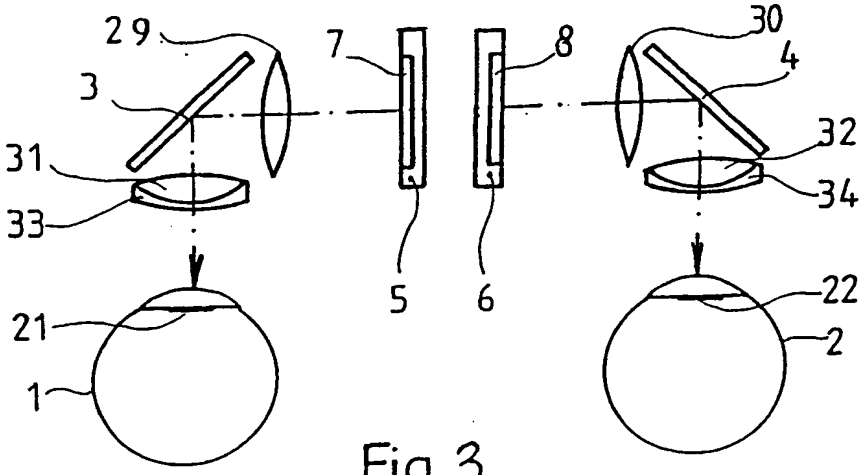

Fig.3

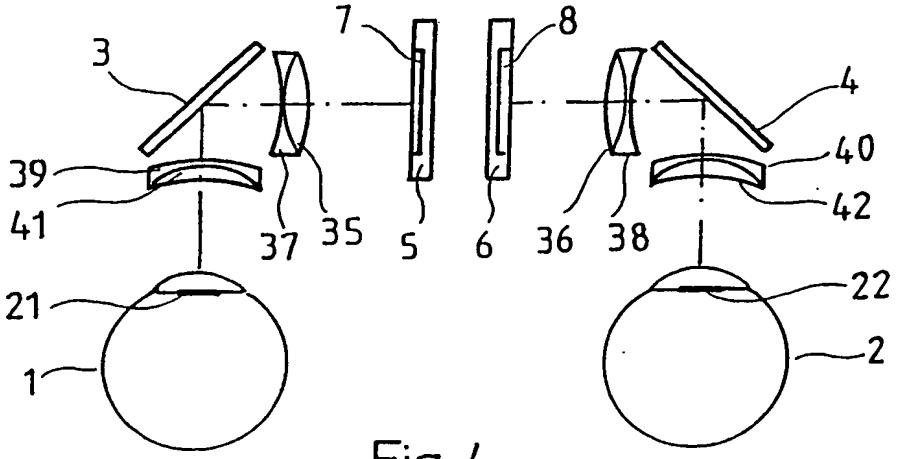

Fig.4

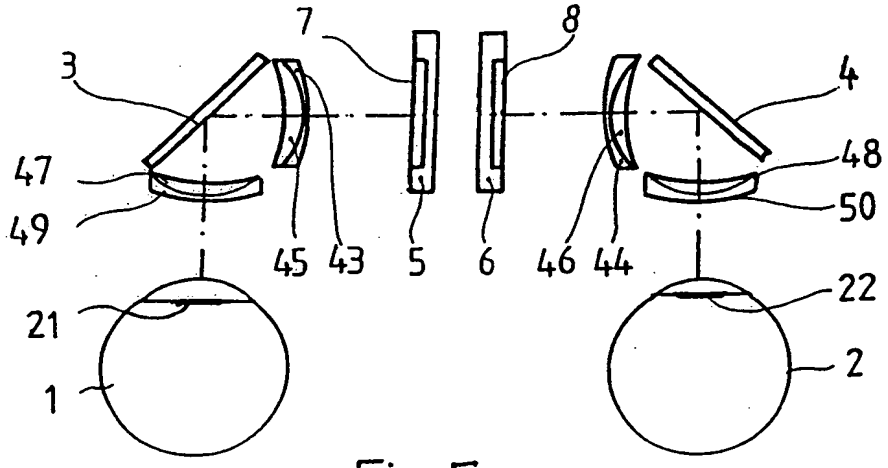

Fig.5

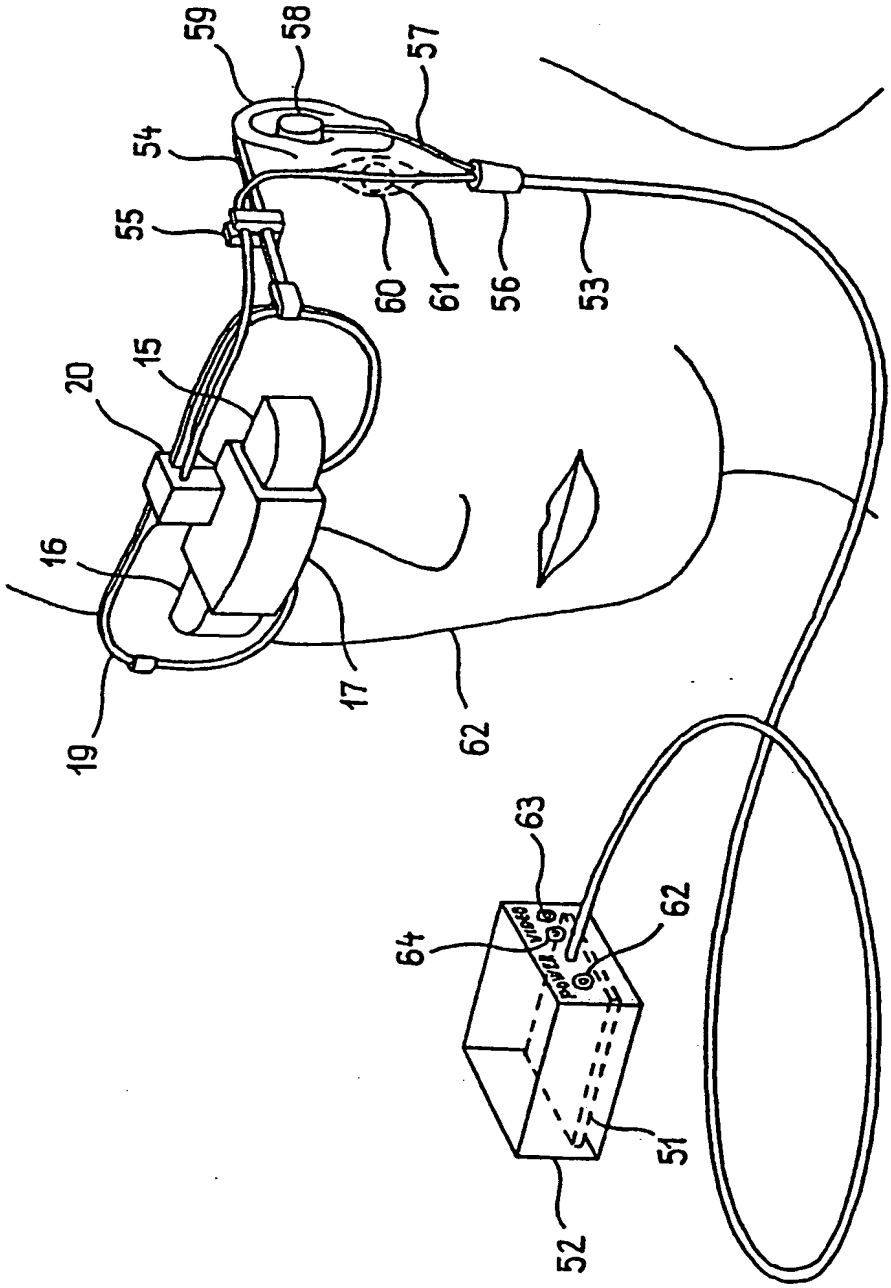

Fig.6

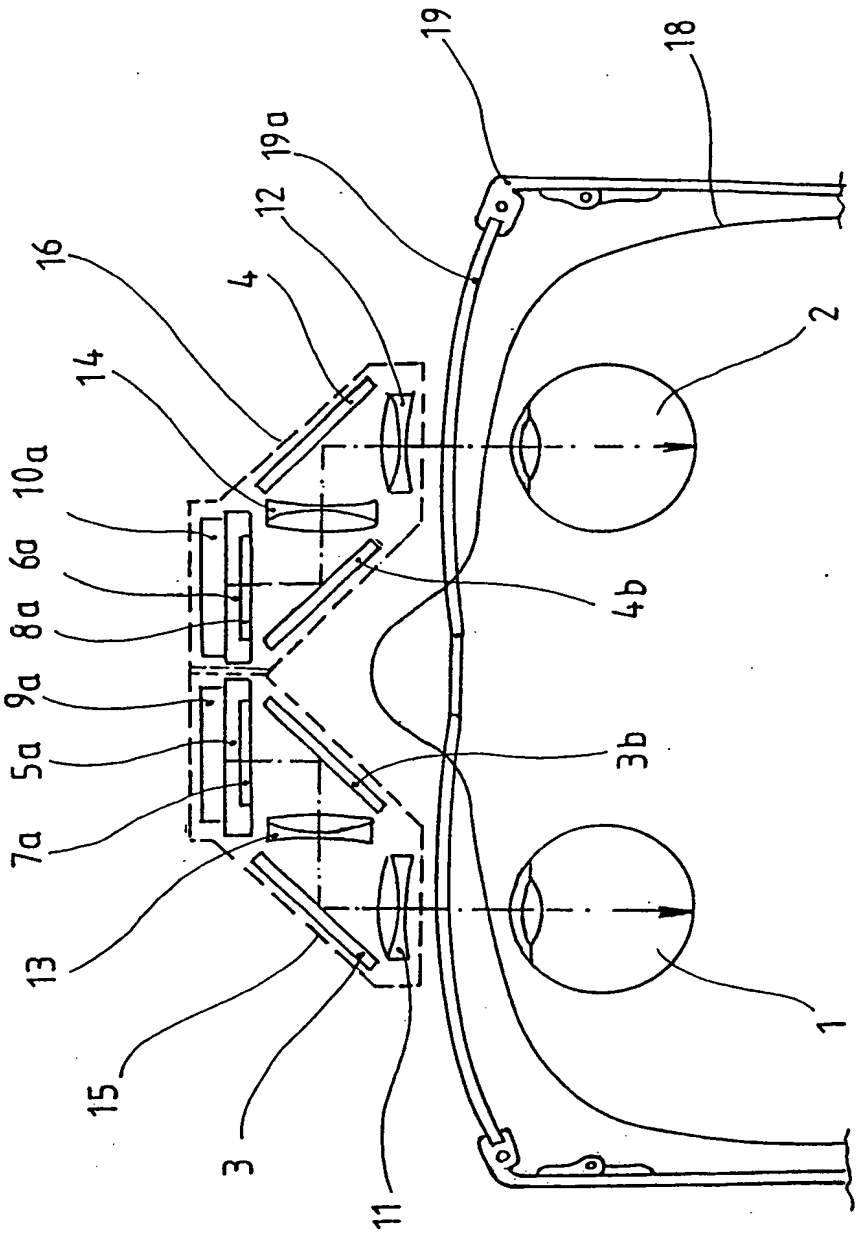

Fig. 7

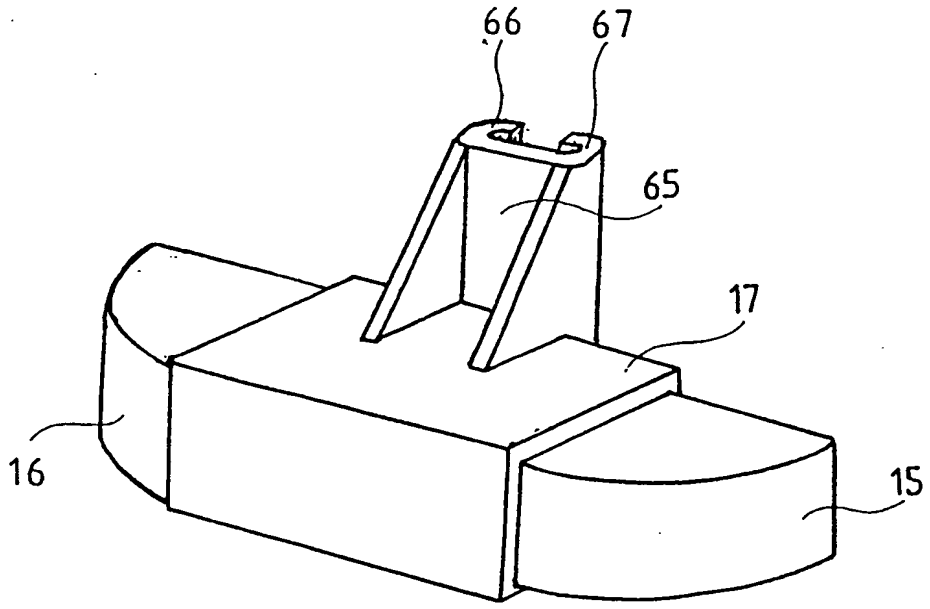

Fig. 8a

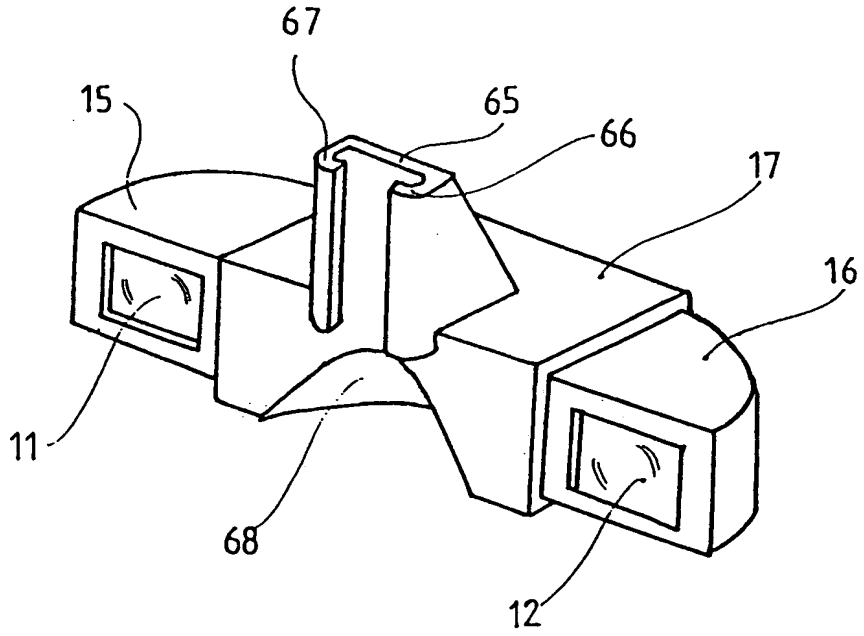

Fig. 8 b

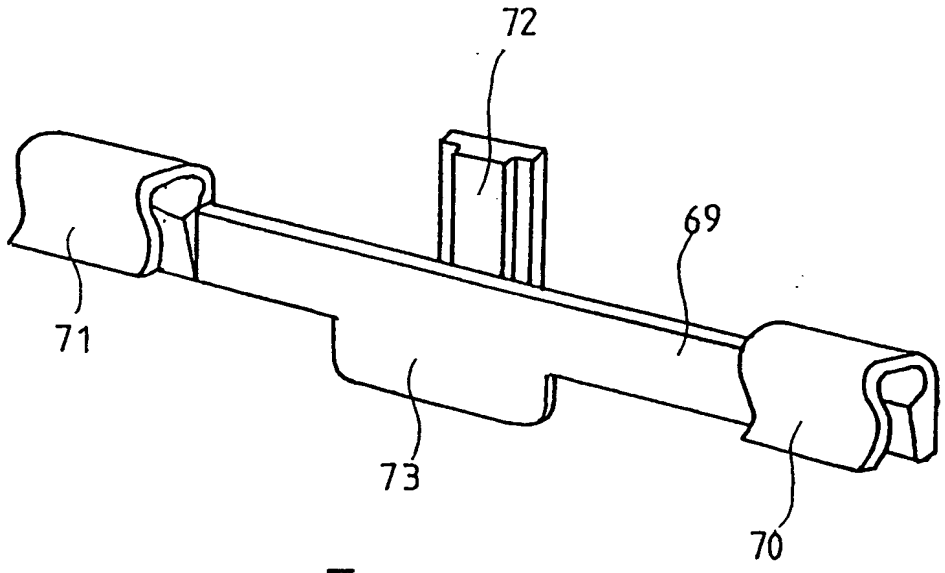

Fig. 9a

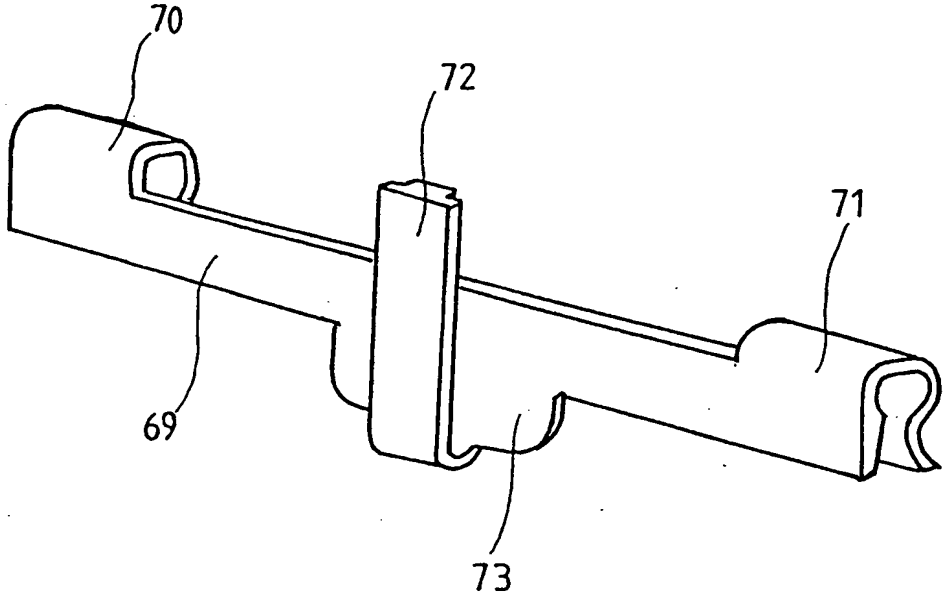

Fig. 9b

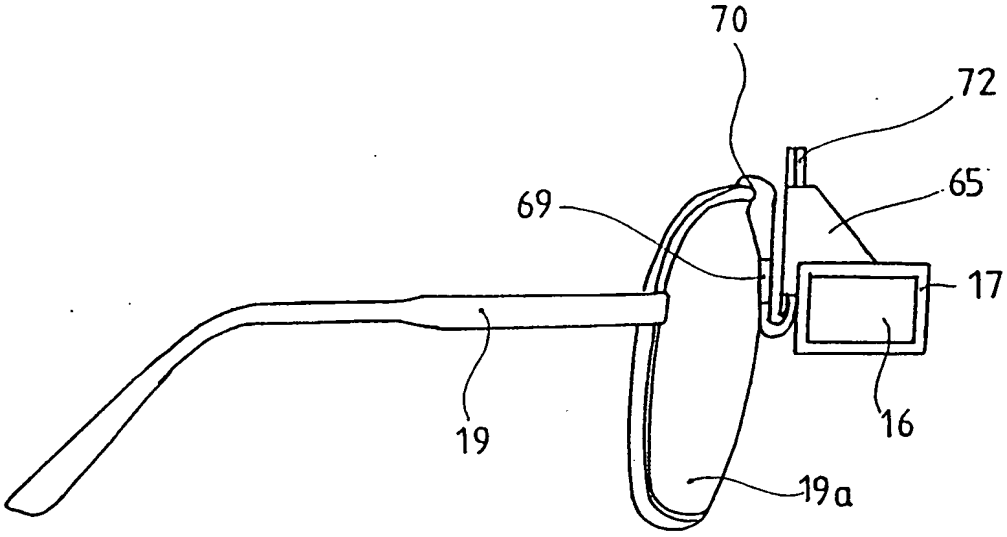

Fig.10.

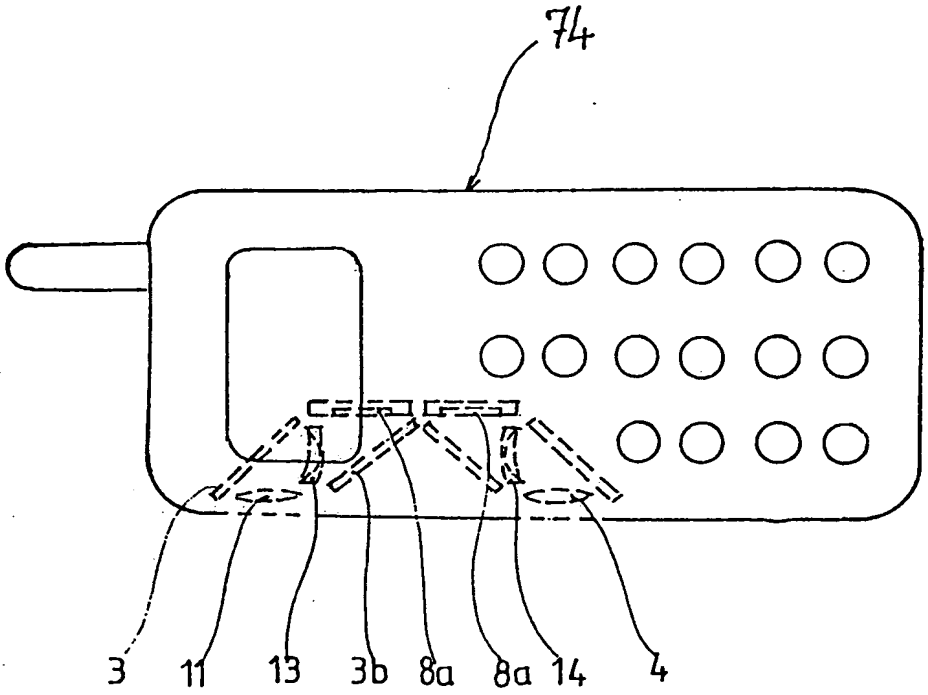

Fig.11

INTERNATIONAL SEARCH REPORT

International Application No
PCT/HU 97/00067

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G02B27/01

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 95 24713 A (OPTICS 1 INC) 14 September 1995	1,2
A	see page 22 - page 25; figures 6,7	3-10

X	IWAMOTO K ET AL: "AN EYE MOVEMENT TRACKING TYPE HEAD MOUNTED DISPLAY FOR VIRTUAL REALITY SYSTEM" PROC.OF THE INT. CONF. ON SYSTEMS, MAN, AND CYBERNETICS, SAN ANTONIO, OCT. 2 - 5, 1994, vol. 1 OF 3, 2 October 1994, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, pages 13-18, XP000530665	1,3
A	see page 15; figure 5	4

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

2

Date of the actual completion of the international search	Date of mailing of the international search report
16 February 1998	11. 03. 98
Name and mailing address of the ISA	**Authorized officer**
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	von Moers, F

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Inter[illegible]nal Application No
PCT/HU 97/00067

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 371 556 A (HISASHI SUWA ET AL.) 6 December 1994 cited in the application see column 5, line 1 - line 30; figure 8B	3-9
A	US 5 546 227 A (YASUGAKI MASATO ET AL) 13 August 1996 see column 17, line 28 - column 18, line 36; figures 11,12,14	3-9
X	EP 0 539 907 A (SEGA ENTERPRISES KK) 5 May 1993	11
A	see column 7, line 32 - column 8, line 32; figure 4 see column 12, line 27 - line 40	12,17
A	WO 95 04435 A (HOLAKOVSZKY LASZLO ;NAGYKALNAI ENDRE (HU); KEZI LASZLO (HU)) 9 February 1995 see page 10 - page 11; figure 1	11-13,16
A	WO 95 11473 A (KOPIN CORP) 27 April 1995 see figures 1-3	14

2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/HU 97/00067

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/HU 97/00067

1. Claims: 1-10

Head mounted display with fold mirror and colour corrected lens system.

2. Claims: 11-17

Head mounted display. Two displays are arranged side by side and each light path comprises two specially arranged fold mirrors. Housing details.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/HU 97/00067

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		EP 0821257 A	28-01-98
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